MAKING SPACE: INNOVATIVE WAYS TO FIT MULTIPLE MODES WITHIN NARROW CROSS SECTIONS

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ABSTRACT

Increasingly in New Zealand, there is a desire to provide road space for a range of different road users, including cycles, buses, and light rail. For many typical NZ road corridors (e.g. a standard 20m road reserve) it can seem difficult to achieve this. However, many overseas examples offer inspiration (sometimes unconventional) for ways forward.

This paper collates a wide variety of different road re-allocation treatments (from literature review and overseas study trips), to provide ideas and guidance for tackling similar problems in New Zealand. As well as more conventional options (such as: removing parking, narrowing traffic lanes, and making one-way streets), the paper will also examine some more creative treatments observed overseas (such as: traffic lanes being used as part-time tram platforms, single-lane two-way busways, and “2-minus-1” roads).

In addition to describing their respective design aspects, some of the advantages and disadvantages of each option will be discussed as well. In some cases, changes to NZ traffic legislation may also be required to allow certain innovations to be implemented. For many, extensive public education will also be necessary to successfully introduce them in New Zealand.

1 INTRODUCTION

Since the widespread adoption of the automobile in New Zealand (NZ), the typical allocation of road space has been a footpath, a parking lane and a travel lane on each side of the centreline. The parking lane is omitted where auxiliary turn lanes have been added for capacity reasons.

In recent years there has been an increasing demand for a more equitable distribution of road space including public transport, walking, cycling, shared spaces, and streetscape features such as landscaping. For many typical New Zealand road corridors (e.g. a standard 20m road reserve) it can seem difficult to achieve space for all of these demands. However, many overseas examples offer inspiration (sometimes unconventional) for ways forward.

While there are numerous road design guides available to New Zealand practitioners (e.g. the Austroads series of guides), relatively little discussion is afforded in them to options for reallocating space. A few local studies have considered certain aspects of the issue; for example, Powell *et al* (2015) investigated the merits of reallocating kerbside parking to provide for other transport uses. Meanwhile Harvey *et al* (2012) looked at options for bus priority treatments. Internationally, some guidance is available; for example, the Irish *Cycle Design Manual* (National Transport Authority 2011) provides advice on how to find room for cycling on a roadway.

This paper attempts to begin addressing that gap by collating a wide variety of different road re-allocation treatments (based on literature review and overseas study trips), to provide ideas and guidance for tackling similar problems in New Zealand. While some have already been applied in various locations in New Zealand, others are untested in a local setting and may require changes to existing New Zealand traffic legislation and/or extensive public education to successfully introduce them.

2 TREATMENT OPTIONS

2.1 Overview

The remainder of this paper will summarise the treatments identified by the authors for creating additional space within the road corridor. Table 1 briefly describes all of the treatments; due to space limitations, only some of the more novel ideas (to New Zealand at least) will be discussed in more detail (denoted with an asterisk next to their treatment number); many others have been discussed in a New Zealand context elsewhere (e.g. shared spaces in Karndacharuk *et al* 2014; HOV lanes in Brown & Paling 2014; Tidal flow lanes in Rice & Cooney 2013; dynamic cyclist warning signs in Gardener & Kortegast 2014). In addition to describing their respective design aspects, some of the advantages and disadvantages of each option will be discussed as well. In some cases, changes to NZ traffic legislation and supporting education will be required to allow certain treatments to be implemented here and this will be identified as far as possible.

A number of common approaches have been considered here, namely:

- Can an existing cross-section element be removed completely?
- Can an existing cross-section element be reduced in size?
- Can a space be shared by multiple uses on a permanent basis?
- Can a space be shared by multiple uses by allocating users at different times?
- Can some road users be removed from a route, either permanently or on a part-time basis?

Where necessary, speed management allows sharing of space to be undertaken in a sufficiently safe manner, either on its own or in conjunction with other treatments presented here.

Note: all images in this paper are by the primary author unless otherwise stated.

Table 1: Options for making space *(NB: 'X' indicates likely benefits; '?' indicates possible benefits, depending on context)*

No.	Treatment Name	Description	Examples	Could provide Benefits for				
				Ped'ns	Cycles	Buses	Trams	M.Vehs
1	***Parking lane removal***	Remove one or both on-street parking lanes - or indented parking bays	Various arterials in Christchurch	?	?	?	?	
2*	***Narrowing traffic or parking lanes***	Adjust wide traffic lanes to be narrower, typically 3.0m for through lanes, can be slightly less for turning lanes	Various arterials in Auckland		?	?	?	
3	***Clearways***	Parking lanes restricted at certain times to become traffic or transit/bus lanes	Various in Akld/Wgtn/Chch. La Trobe St, Melbourne		?	?		?
4	***Narrow flush median with cycle lanes***	Provide only a 1.0m wide flush median with traffic lanes and cycle lanes. Still allows room for passing traffic to go around waiting vehicles by using the cycle lane space.	Northcote Rd, Christchurch		X			?
5*	***Road Diet***	Typically convert four-laned road to two lanes plus flush median (with ped'n islands) & cycle lanes "reduce number of lanes"	Kaikorai Valley Rd, Dunedin	X	X			
6*	***One-way street***	Remove a traffic lane to provide for other facilities (e.g. cycleway, busway) while maintaining traffic access (could be 2-way for certain modes)	Royal College St, London UK; York Ave, Vancouver BC		?	?	?	
7	***Low speed street***	Low speed street (typically 30km/h) where all vehicles share the same roadway; could also include "bicycle priority streets" (e.g. *fietsstraat*, bicycle boulevards, neighbourhood greenways).	Many in Europe, USA	X	X	X	X	
8*	***Informal contra-flow cycling***	Allow contraflow cycling along an otherwise one-way street (typically 30km/h max) by means of signage and markings at entry/exit points only	Victoria St, Adelaide, SA; Various streets in Bristol, UK;		X			
9	***Shared zone / Shared space***	Low speed area (typically 10km/h) where all modes (including pedestrians) share the same space. May restrict certain types of vehicles	Auckland various; Locking St, Nelson	X	?			
10	***Pedestrian mall***	Remove motor traffic from street (cyclists sometimes still allowed)	Rundle Mall, Adelaide, SA	X	?			
11	***Transit mall***	Remove general traffic from street but allow buses and/or trams through	Manners St, Wellington; Cashel St, Christchurch. Throughout Europe	X	?	X	X	
12*	***Temporal street restriction***	Limit street to access by motor vehicles only for limited part of the day; use signs/gates to restrict access	Chester St, Christchurch; central zone Rome, Italy, Te Taou Cres Akld (Beach Rd cycleway)	X	X			
13	***High Occupancy Vehicle (HOV) lane***	Reallocate traffic lane for use by buses and possibly other vehicles with at least 2/3/4 occupants	Northern motorway, Auckland			X		

No.	Treatment Name	Description	Examples	Could provide Benefits for				
				Ped'ns	Cycles	Buses	Trams	M.Vehs
14*	***Part-time tram / bus platforms***	Signals stop raised traffic lane to allow pedestrians to board/disembark centrally-running tram or bus	Freiburg, Germany; Vienna, Austria	X		?	X	
15*	***In-lane bus stops***	Buses stop directly in outer traffic lane to board/disembark passengers	Fendalton Rd, Christchurch; Hills Rd, Chch (previous)		?	X	?	
16*	***"2 minus 1" road***	Narrow road is converted to single traffic lane with cycling shoulders either side (typically 30km/h in urban areas; 60km/h in rural)	Various in the Netherlands and Denmark; City of Yarra, VIC Australia		X			
17*	***Single-lane two-way busway***	A (usually) single centrally-located bus lane is shared by buses in both directions, either by time (signals, line-of-sight scheduling, peak-hour direction) or alternating sections	Eugene, OR, US; Enschede, Netherlands; Langstrasse, Zurich CH			X		
18*	***Shared traffic/tram lanes***	Tram lines run along existing traffic lanes (typically low-speed environment); traffic has to stop when trams stop	Amsterdam, NL; Zurich CH				X	
19	***Managed shoulder hard-running lanes***	Variable signage allowing the use of emergency hard shoulders as an additional traffic lane or transit lane	UK, Germany			?		?
20	***Tidal direction traffic lanes***	Using lane-use signs to reallocate traffic lanes to alternating directions at different times (sometimes also with moveable barriers or lane lights)	Akld Harbour Bridge; Panmure Bridge, Akld; Curletts Rd, Chch (temporary)					X
21*	***Intermittent bus lanes***	Variable signing of outer lane as bus lane as buses approach, then allow ordinary traffic to use it after the bus has passed	Alameda da Universidade, Lisbon, Portugal; Toorak Rd, Melbourne, Australia			X		X
22	***Dynamic cyclist warning signs***	Flashing warning signs to indicate presence of cycles in road sections ahead (could be bridge or tunnel); activated by passing bike	SH60 Nelson; SH2 Wellington; SH101 Oregon Coast, US		X			
23*	***Sharrow markings***	Cycle logo markings with chevron arrows, denoting shared use of road space by motorists and cycles.	Trial sites in Auckland, Palm. North, Wellington, Nelson, Dunedin		X			
24*	***Single-lane traffic through constriction***	Provide alternating access for motor traffic through constriction to allow for permanent walk/cycle shoulders; possibly controlled by signals	Harakeke St bridge, Chch; Mina Rd tunnel, Bristol UK	X	X			
25*	***Intelligent / area-wide parking management***	Technology and management approaches applied to improve the economic efficiency of parking allocation, thus freeing up some parking space for other uses	*SFpark*, San Francisco, US	?	?	?	?	X

2.2 Treatment Options

2.2.1 Narrowing Traffic or Parking Lanes (Treatment No.2)

Narrowing traffic lanes may provide space for geometric features that enhance safety or operations such as medians, turn lanes, or special vehicle lanes. Harwood (1990) reported on a survey of 141 state and local agencies in the U.S. including 6 agencies that had 2.4m lanes, 60 that had 2.7m lanes, and 121 that had 3.0m lanes. None reported negative safety effects. A second part of Harwood's report included a controlled study of projects where lanes were narrowed to add travel lanes or turn lanes, and again no negative safety effects could be identified.

According to McDonald (2012), Yarra (Australia) has successfully implemented 2.5-2.8m wide lanes, enabling the installation of cycle lanes generally wider than 1.5m. McDonald states that "vehicle tracking has become more consistent, traffic speed lowered, and cyclists given more separation thus creating a safer environment for all users."

Kerbside parking lanes are also traditionally larger than needed for the majority of light motor vehicles, often 2.0m or greater. However the current Australasian parking standard AS/NZS 2890 indicates that the 99.8th percentile car width is only 1.94m, while the 85th percentile is 1.77m. Therefore it may be feasible to have parking spaces only 1.8-1.9m wide. While allowance is still needed for car doors opening, experience has shown that it is better to incorporate this width into the adjacent traffic/cycle lanes, to encourage better parking discipline (i.e. lateral position).

Figure 1: Traffic/parking lanes reconfigured (faded markings) to install cycle lane, Christchurch

Advantages

- Narrower lanes may reduce speeds and therefore improve safety outcomes
- Narrower parking lanes improve consistency of parking discipline (lateral position)

Disadvantages

- On certain routes and below approximately 2.9m, there can be operational difficulties for large vehicles such as buses, especially if there is no other adjacent lane to encroach upon
- Narrower parking spaces may be impractical for parking heavy vehicles

Legal Considerations

- A legal traffic lane has to be at least 2.5m wide

2.2.2 Road Diet (5)

A road diet is known by many terms including “road space reallocation” and “road right-sizing”. Road diets can have safety, operational, and quality of life benefits. The term “diet” may imply an undesirable reduction in capacity, but typically it results in broader benefits for a wider range of road users with little effect on through-traffic (see Figure 2).

Figure 2: Road diet conversion from two traffic lanes, Kaikorai Valley Rd, Dunedin

The classic road diet involves a reduction from four undivided travel lanes to two through-lanes and a right-turn lane within a flush median plus new cycle lanes on each side (see Figure 3). However there are many other variations that can include narrowing or removing existing travel lanes to provide additional facilities and unbalanced combinations of lanes in each direction.

In the USA, road diets have been implemented on corridors with up to 26,000 vehs/day (two-way). An evaluation of 45 locations in three U.S. states indicates a combined estimated crash reduction of 29% (Knapp *et al*, 2014), with a suggested range of 19-47% depending on site-specific factors.

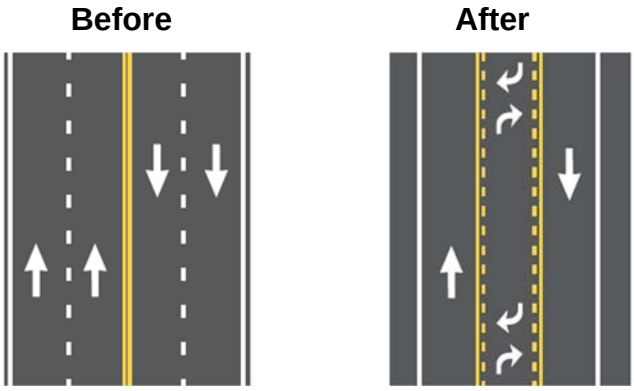

Figure 3: Typical Road Diet (adapted from FHWA, 2014)

Advantages

- For roads that have excess capacity, reallocation is a more efficient use of public space
- Dedicated space for other uses provided at a lower cost than providing new space

Disadvantages

- Loss of capacity (although typically less than the number of traffic lanes)

Legal Considerations

- None

2.2.3 One-way Street (6)

If the introduction or retention of parking or special traffic facilities (e.g. bus/cycle lane) is desired along a corridor, removal of general traffic flow in one direction may resolve space constraints while still providing some continuing access to land uses along the route (see Figure 4).

Figure 4: Removal of two-way traffic in London to allow for a separated cycleway

Advantages

- Could allow on-street parking to be maintained
- Indirectness of general travel may reduce motor traffic levels and transfer to other modes

Disadvantages

- Can increase travel time and distance for some users

Legal Considerations

- Usually need a bylaw to introduce a one-way restriction

2.2.4 Informal Contra-Flow Cycling (8)

Contra-flow cycling along an otherwise one-way street is typically by means of lane markings or physical separation along the entire route (sometimes with additional treatments at the entry/exit points). While this in itself is a useful way to provide some two-way connectivity for cycling in a relatively limited space, contra-flow cycling could also be provided on low-volume, low-speed streets simply by means of signage and markings at the points of entry only, or occasionally along the route (see Figure 5 and Figure 6).

Advantages

- If accompanied by 30km/h speed reduction, improvement in safety
- Reduced travel time for people cycling
- Formalisation of existing practice by people cycling

Disadvantages

- Can violate driver expectation unless side streets have effective warning signs/markings
- May still be uncomfortable for cycling if traffic speeds and/or volumes remain high

Figure 5: Contra-flow cycling along one-way street, Strasbourg, France

Figure 6: Contra-flow cycling allowed in this lane, Adelaide, Australia

Legal Considerations

- May be possible with current signage, but may need bylaw to introduce restrictions and exemptions

2.2.5 Temporal Street Restriction (12)

If there is a desire to allow traffic on a street only at particular times (e.g. for deliveries, or for day-time shopping), then access to the street by motor vehicles could be limited for the remainder of the day, using either signs (e.g. Figure 7) or gates/barriers to restrict access when required.

Figure 7: Part-time traffic restricted area, controlled by electronic signs, central Rome, Italy

Advantages

- Increased retail business due to greater pedestrian patronage when street is closed
- Increased safety of pedestrians when motorists are absent
- Ability to use road space for other activities, e.g. markets, play areas

Disadvantages

- Possible non-compliance by some motorists unless enforcement or barriers

Legal Considerations

- Usually need bylaw to introduce the restriction

2.2.6 Part-time Tram / Bus Platforms (14)

While road-space might be reallocated to introduce separate tram/bus ways, there may be limited room at stops to provide additional passenger boarding space. A part-time platform is a raised traffic lane adjacent to centrally-running tram or bus ways that stops traffic when required to allow pedestrians to board/disembark to and from the footpath (see Figure 8).

Figure 8: Traffic waits for passengers to board/disembark trams, Freiburg, Germany

Advantages

- Extra space is not required at stops
- Improved pedestrian safety accessing public transport in middle of street

Disadvantages

- May require significant public education
- Traffic delays, especially if PT services are frequent

Legal Considerations

- May be possible with Land Transport (Road User) Rule

2.2.7 In-Lane Bus Stops / Bus Boarders (15)

If there is no parking/shoulder space along a road, it may be difficult to provide bus stops out of the way of traffic lanes; such bus bays also make it difficult for buses to re-enter the traffic stream. The alternative is for buses to stop directly in the outer traffic lane to board/disembark passengers (see Figure 9). Any vehicles behind may have to either wait for the bus to move or shift to an adjacent travel lane (if available).

Figure 9: In-lane bus stop with cycle lane behind island, Copenhagen, Denmark

Figure 10: In-lane bus stop, Fendalton Rd, Christchurch, with bike bypass

Advantages

- Extra corridor space is not required at stops

Disadvantages

- May require significant public education
- May have to provide bypass facilities for cyclists (see Figure 10)
- Traffic delays (especially if only one through-lane exists)

Legal Considerations

- None

2.2.8 "2-Minus-1" Road (16)

Narrow, low volume, low speed roads with high cycling demand can be converted to a single traffic lane with cycling shoulders either side. These are similar in concept to narrow country roads where only the centre of the road is sealed and motorists use the unsealed shoulder when encountering opposing traffic. Typically 2-minus-1 roads are 30km/h in urban areas (Figure 11) and 60km/h in rural areas (Figure 12). A rural trial of a 2-minus-1 road was undertaken in the Waipa District in 2015. Unfortunately, the site was less suitable than hoped for, with higher traffic volumes and speed environments than desirable. Advance publicity and education of the trial was also somewhat limited and the resulting confusion and concerns by locals about the new signs and markings saw the trial terminated early.

Advantages

- Cost of road widening is avoided, although localised widening at curves may be needed

Disadvantages

- May require significant public education
- Sight-distance issues at blind curves (may need localised widening)
- Does not address higher volume rural or urban roads
- Likely to require substantial education and marketing

Figure 11: Urban (30km/h) *fietsstraat* ("bicycle street") in Utrecht, Netherlands

Figure 12: Rural (60km/h) 2-minus-1 road near Enschede, Netherlands

Legal Considerations

- May need trial signage/markings to explain concept

2.2.9 Single-Lane Two-Way Busway (17)

A constrained road corridor may only have enough space for one additional priority bus lane. To allow for benefits to buses in both directions, such a bus lane (usually centrally-located) could be shared. Separation of buses in opposing directions can be done by a variety of means, including separating by signals, line-of-sight movements between passing spaces (Figure 13), usage only in the peak-hour direction, or by alternating physical sections (Figure 14).

Figure 13: Two-way central bus lane splits at a bus stop, Eugene OR, US

Figure 14: Central busway changes direction mid-block, Enschede, Netherlands

Advantages

- Can provide many of the benefits of separate directional busways using less space

Disadvantages

- May still have to rejoin general traffic lanes at some point.
- May require training of bus drivers

Legal Considerations

- Usually need bylaw to designate special vehicle lane

2.2.10 Shared Traffic/Tram Lanes (18)

In constrained urban areas, especially where traffic volumes are low, it might be feasible to allow tram lines to run along existing traffic lanes (typically in a low-speed environment). Unless there is an adjacent lane, traffic has to stop when trams stop (see Figure 15 and Figure 16).

Figure 15: Cars drive through the tram stop, Zurich, Switzerland

Figure 16: Shared traffic and tram lanes, Amsterdam, Netherlands

Advantages

- Delays to traffic may reduce general traffic volumes and cause modal shift

Disadvantages

- May require significant public education
- Need to watch potential tram-track hazard to cycles if no separate cycling facilities
- Could cause congestion if tram breaks down in the traffic lane

Legal Considerations

- No specific road requirements. Legally, traffic must not impede light rail in NZ

2.2.11 Intermittent Bus Lanes (21)

A common concern with dedicated bus lanes is that they are often relatively under-utilised in congested traffic compared with adjacent lanes. Intermittent bus lanes address this issue by using dynamic signs and markings (see Figure 17) to designate a lane as a bus lane as buses approach, then allowing ordinary traffic to use the lane after the bus has passed.

According to Eichler and Daganzo (2006), *"delays are more than offset by the benefits to bus passengers as long as traffic demand does not exceed by much the maximum flow possible on the non-special lanes… The main factors determining whether an intermittent system saves time*

are: the traffic saturation level; the bus frequency; the improvement in bus travel time achieved by the special lane; and the ratio of bus and car occupant flows".

Advantages

- Maintain capacity for traffic with low-frequency bus services
- Free buses from traffic interference

Disadvantages

- May require significant public education
- Increases delay for general traffic
- On higher-frequency bus routes, may have to switch to permanent facility

Figure 17: Dynamic signage and in-pavement lights used to indicate intermittent bus lane on Alameda da Universidade, Lisbon, Portugal (Viegas *et al* 2007)

Legal Considerations

- May require designation as a special vehicle lane

2.2.12 Sharrow Markings (23)

There are situations where no specific cycle facilities are provided (sometimes because they're not appropriate in a low-volume environment) and thus riders are expected to share the same space as motorists. Sharrows (or "share arrows") are markings that indicate to motorists the likely presence of people cycling in the lane (see Figure 18 and Figure 19), as well as encouraging cyclists to position themselves more clearly in the traffic lane ("taking the lane" if need be).

Advantages

- Improve behaviours and expectations of both motorists and cyclists

Disadvantages

- May require significant public education
- May be used inappropriately when a better cycle facility is warranted

Figure 18: Sharrow markings in a busy CBD street, Wellington

Figure 19: Sharrows on a quiet street, Adelaide, Australia

Legal Considerations

Sharrows are currently proposed for general ratification in mid-2016 following formal trials in five cities throughout New Zealand.

2.2.13 Single-Lane Traffic Through Constriction (24)

If there is a short section of road (including bridges and tunnels) where space is constrained , it may be appropriate to provide alternating or shared access for motor traffic through the constriction to allow for permanent walk/cycle shoulders (see Figure 20). Signage may be sufficient to manage this, although busier streets could possibly be controlled by signals.

Figure 20: Cycle lanes either side of a single traffic lane, Mina Rd tunnel, Bristol UK

Advantages

- Avoids the need for significant widening cost, while improving pedestrian/cycle safety

Disadvantages

- Potential for large delays on busier streets
- May require significant public education

Legal Considerations

Use signage similar to one-lane bridges and single-lane traffic calming devices

2.2.14 Intelligent / Area Wide Parking Management (25)

Parking management strategies that reflect the real value of the road space used for parking can improve the economic efficiency of road space allocation. One such application is the *SFpark* pilot programme implemented by the San Francisco Municipal Transportation Agency (SFMTA) in 2014 (see Figure 21). This implemented demand-responsive pricing of both on- and off-street facilities to meet parking occupancy targets.

It was found that this system reduced the amount of time people spend searching for a parking space and thus reduced congestion and circulation, improved traffic flow, speed and reliability and improved safety for all road users. Incidents of illegal parking, the number of parking tickets issued and the average hourly rate people pay for parking were all also reduced. Implemented well, such a system has the potential to free up both parking space and road capacity for other uses.

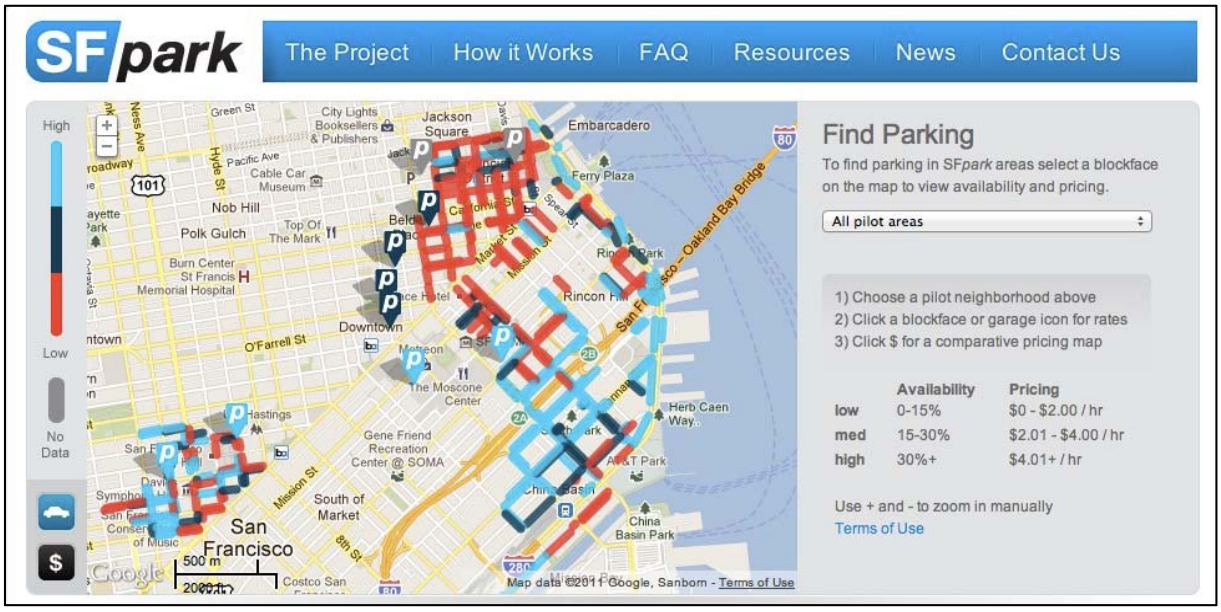

Figure 21: Screenshot of *SFpark* online parking management system (SFMTA 2016)

Advantages

- Traffic congestion benefits from reduced parking searching
- Optimises existing parking space to avoid additional construction

Disadvantages

- Can be complex to manage on a large scale

Legal Considerations

Bylaws may need to allow for dynamic parking charging rates

3 CONCLUSION

The above list provides an extensive but not completely exhaustive list of options for creating additional space within existing road corridors. Essentially most of the treatments boil down to considering options of removing or reducing cross-section elements, or sharing of particular spaces by multiple uses, either permanently or on a part-time basis. While some of them are conceptually straightforward, others may require a change in mind-set by both practitioners and the general public for them to be implemented and used successfully.

It is recommended that New Zealand road controlling authorities consider these treatment options when struggling to provide space for all desired cross-section elements. Trials of some of them in a New Zealand context would be useful to determine their wider applicability. The NZ Transport Agency also need to investigate further what legislative changes (whether changes in road rules or new traffic control devices) may be required to allow for some of the options to be implemented; although in a number of cases it would appear that a simple local bylaw (e.g. regarding special vehicle lanes or prohibited traffic movements) may be sufficient to allow them to occur.

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